April 1991

BEST PRACTICE PROGRAMME

Good Practice Case Study 16

ENERGY EFFICIENCY IN OFFICES

Heslington Hall, University of York

Cost-effective improvements to a listed building.

- Building use rationalised.
- Windows weatherstripped and roof insulation re-fitted.
- Domestic hot water system separated from heating boilers.
- High-efficiency gas-fired baseload boiler added to original oil-fired installation.
- Dual fuel capability minimises heating costs.
- Electronic energy management controls.
- Two year payback period for energy efficiency measures.

The Project

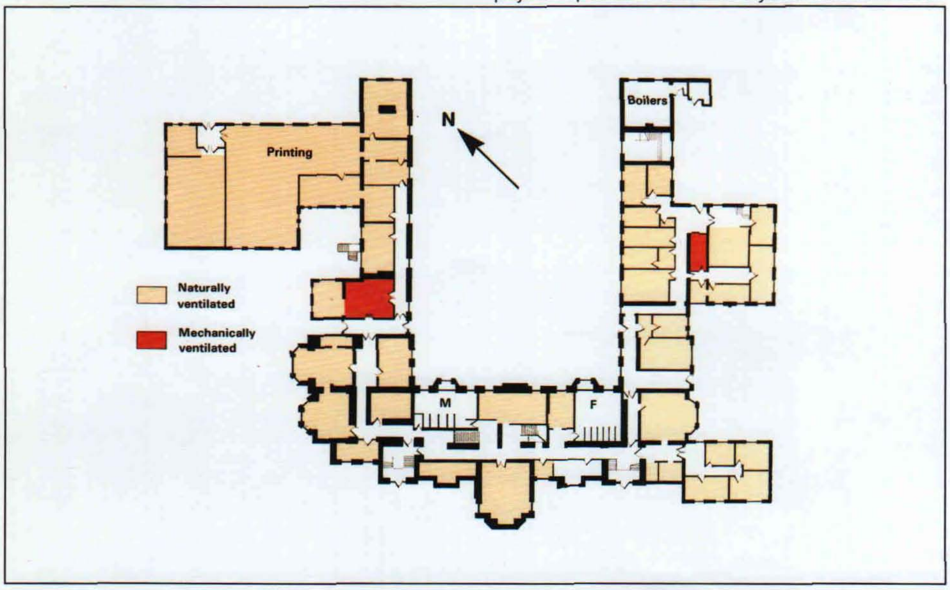
In the early 1960s Heslington Hall was refurbished to become York University's administrative offices. As well as the administrative centre, Heslington Hall initially contained social, teaching and dining facilities. As the University grew, most of these moved elsewhere, but the few that remained operated for 7 days per week, which the offices did not.

Although the heating system was carefully zoned, its operation became inefficient. An energy audit in 1979-80 revealed that its annual fuel consumption per unit area for central heating and hot water was very high. A programme of energy-saving measures as described in the bullet points above was therefore adopted.

The Result

Low-cost measures, including recommissioning the boiler, improved time controls, and relocating weekend uses to other buildings or servicing them independently, reduced annual oil consumption by 30%. The subsequent installation of the new gas boiler, independent hot water system, and new controls, gave a similar saving, to just over 40% of the level immediately before the energy audit.

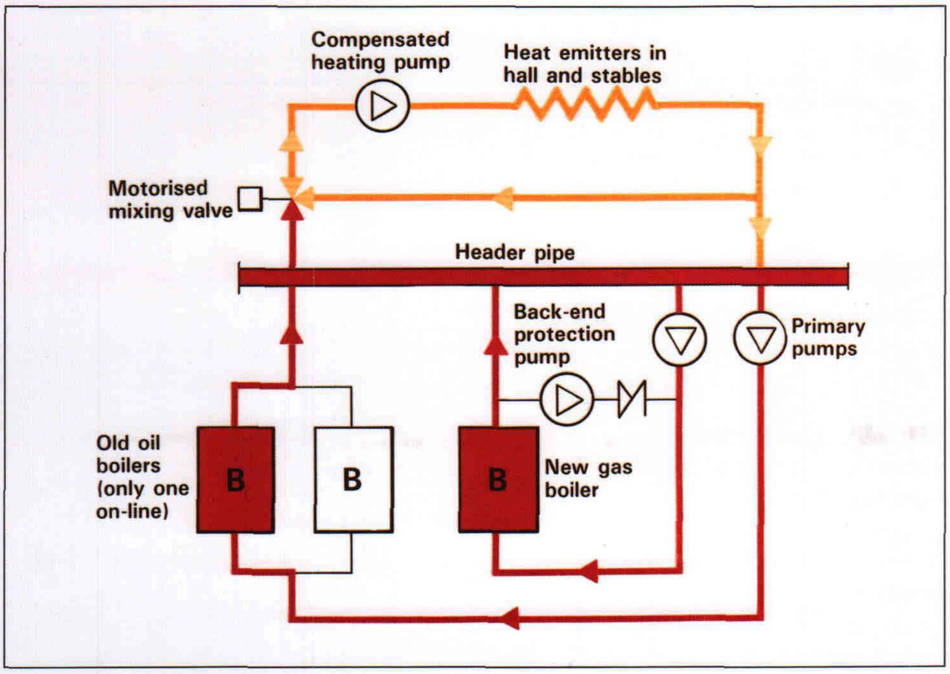
Originally Heslington Hall's annual energy consumption was 'very poor' by the criteria of the CIBSE Building Energy Code Part 4. The combination of technical and management measures has now brought it to a 'satisfactory' level. With the high price of oil at the time of the alterations, a payback period of under two years was achieved.



Heslington Hall. Ground Plan

Energy Efficiency Office
DEPARTMENT OF THE ENVIRONMENT

(R5)
C1/Sfb 33 (56) (Y2)



Heating System Schematic

Heating System

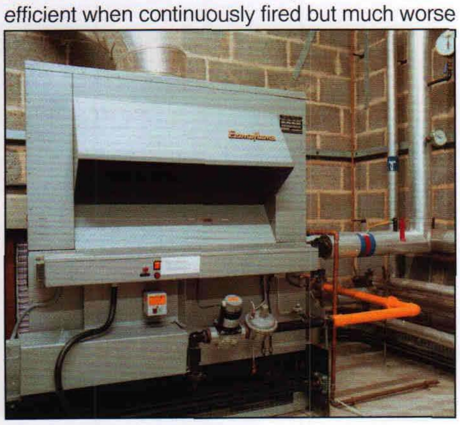
The original heating for Heslington Hall and Stables used thermostatically-controlled fan-convectors, in 13 separate zones with time-switches and local over-rides at reception, plus natural convectors in the smaller rooms. (Since the heating now only runs for normal office hours, this fine degree of zoning is no longer necessary). Where alterations had been made, radiators with thermostatic valves have been added.

The low-temperature hot water (LTHW) circuit was fed from two 372 kW floor-standing cast-iron oil-fired Beeston Colonel boilers in the ground floor plant room. The boilers supplied the hot water calorifier coil directly while the heating circuit was outside-temperature compensated via a 3-way valve with an elderly electronic controller.

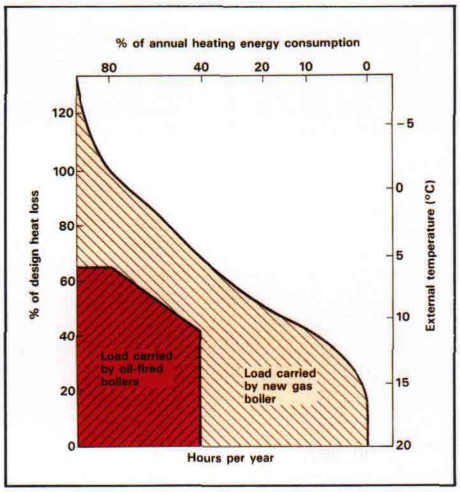
Boiler Alterations

At the time of design, gas was much cheaper than oil, but its supply was limited to 25,000 therms, about 70% of the estimated requirement.

Since it was also felt wise to retain a dual fuel capability, the University decided not to replace one or both of the old boilers (which were 72% efficient when continuously fired but much worse in intermittent operation), but to add a lightweight modulating Econoflame atmospheric boiler (with an efficiency around 80% over much of its operating range) in an adjacent under-used store room, using a roof-mounted Monodraught balanced flue.



An Econoflame Boiler



Heating analysis chart

The largest boiler that could fit the small store room was 282 kW: only two-thirds of the two buildings' design heat loss. It was therefore decided to use it in two modes:

- In mild weather, the new boiler runs alone.
- In colder weather, one of the original boilers (now operated as a duty/standby pair with the standby unit valved-off manually) carries the baseload with the peaks dealt with by the new boiler.

This arrangement reduced the overall capital cost of the alterations and has worked very well. Not only were energy savings greater than predicted, but so were cost savings owing to the high price of oil shortly after completion, and the capital cost of £19,000 was paid back within two years. When the oil price fell in 1985, the proportion of oil-firing was increased — albeit with some drop in thermal efficiency — to minimise the overall energy costs.

Ventilation Systems

The building is naturally-ventilated. Mechanical ventilation plant for the main meeting room is now little used, openable windows having proved sufficient.

Heating and Ventilation Controls

A JEL TOC 4000 controller in the boiler room replaced the earlier compensator and time switches and provides:

- a 7-day heating programme (with optimum start, stop and pump run-on)
- outside temperature-linked compensation with room temperature correction
- linked time control for the boilers, and
- fixed time control for domestic hot water.

To start with the old boilers were simply held-off in mild weather by an outside thermostat. However, this could lead to uneconomic operation (for example when it turns cold outside but the building is already adequately warm, or by under-utilising the original boilers when oil is cheap). As soon as capacity became available, this was replaced by a logic signal from the University's Building Automation System.

Initially, the room temperature correction did not work reliably and rooms were sometimes too cool, giving an anomalously low energy consumption until 1985.

Domestic Hot Water

The original hot water system had a 910 litre calorifier serving kitchens, showers and the main toilets, with electric storage water heaters in remote toilets and in the printing department. Summertime fuel efficiency of the central system was very low.

When the new system was installed in 1983, the kitchen was no longer in use and so the storage capacity of the replacement gas-fired water heater was reduced to 315 litres, which has proved satisfactory.

Lighting

In 1980, the lighting was predominantly tungsten, often with low illuminance levels of 50-150 lux. Since then, most office lighting has been replaced by fluorescent, to the University's standard of 300 lux, (with desk lamps available), while miniature fluorescent fittings have also been installed in corridors and stairs. For decorative effect in this historic building, some tungsten lighting has been retained in key areas, plus new high-intensity discharge uplighting.

Design & Installation

Energy Consultant	RMJM Energy Group
New boiler Installation:	H Pickup & Son
Econoflame boiler	Corvec Ltd (now supplied by Stokvis Ltd)
Water Heater	Andrews Industrial Equipment Ltd
Electronic Controls:	JEL Energy Conservation Services Ltd
Building Automation System	Satchwell
Lighting alterations design and installation:	University of York Maintenance Department

Building Details

Elizabethan building reconstructed in Victorian times. Refurbished 1962

Floors: 3 office floors + smaller top floor.	
Gross floor area	4475 m² 48170 ft²
Treated floor area	4470 m² 48110 ft²
Nett floor area	2890 m² 31130 ft²
Typical number of occupants	150
Typical hours of use:	8.30am-6pm weekdays

Fabric	U-value (W/m²K)
Solid walls	1.2
Single glazing (clear glass)	6.0
Roof (estimated average)	1.0

Heating

Cast-iron boilers (old)	2 x 372 kW
Econoflame gas boiler	1 x 282 kW

Optimum start/stop and compensation of low temperature hot water circulation. Cast-iron boilers held off by electronic building automation system unless if weather is severe or oil is cheap.

Hot Water

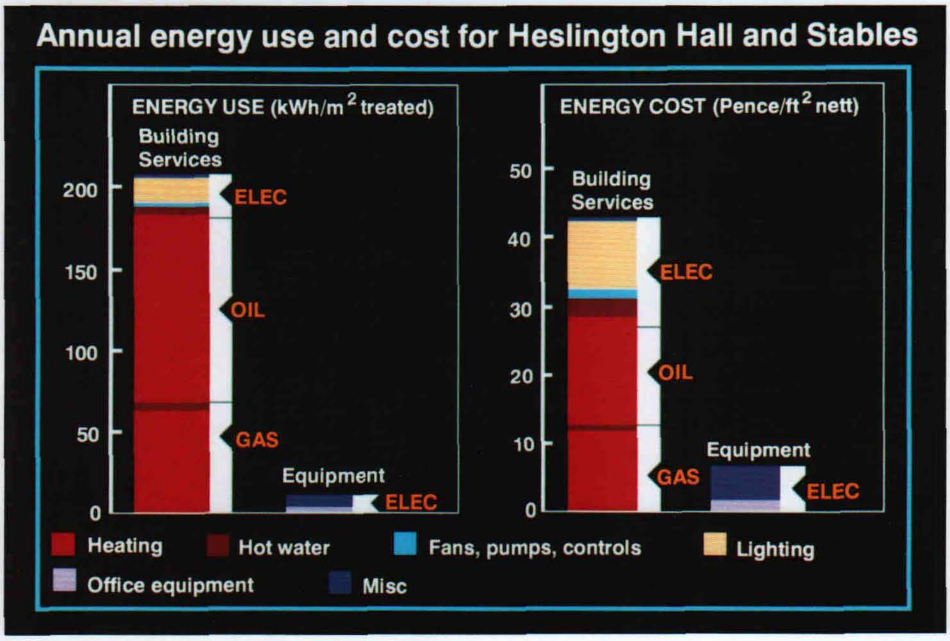
Separate gas-fired time-controlled 315 litre Andrews storage water heater, 22 kW Input, for main toilets and showers.
3 x 6 kW local electric storage cylinders.

Ventilation and Air Conditioning

Naturally ventilated.

Lighting

Good daylight in many areas.
Fluorescent typically 300 lux 10 W/m²
Manual light switching only.



Analysis of Energy Use and Energy Cost

From August 1986 to September 1987 (2553 degree-days) 307,500 kWh of gas and an estimated 5000,000 kWh of oil and 170,000 kWh of electricity were consumed. After allowing for the degree-days, the total of 219 kWh/m² of treated area (181 kWh/m² fossil fuel and 38 electricity) is within the CIBSE Energy Code Part 4's 'satisfactory' category for naturally-ventilated offices.

The diagram above gives a detailed breakdown of energy use and cost. Annual fuel costs were £6850 for electricity, £4010 for gas and £4450 for light oil: 38, 13 and 14 pence per square foot nett respectively. The electricity cost of 3.8 p/kWh is low for this size of building (5p is typical) as it is fed from the University's main campus system.

Heating 179 kWh/m²

Although the heating energy use is fairly high for a case study building, it is relatively good for a poorly-insulated traditional construction with single-glazing, and a dramatic reduction from the 435 kWh/m² (including hot water) immediately before the energy audit. The new figure includes 3 kWh/m² for local electric heaters used out-of-hours and in a few exposed rooms where the central heating is under-sized.

Hot Water 9 kWh/m²

This consists of 5 kWh/m² in the gas-fired heater and 4 kWh/m² in the 3 local electric heaters. This is a fair performance as the gas-fired system includes a considerable length of circulating pipework.

Fans, Pumps & Controls 3 kWh/m²

Energy consumption is about average for the size and type of building and the systems installed. The low-speed fans in the Weatherfoil fan-convector heaters are included.

Lighting 16 kWh/m²

Energy use is well under average for the case studies, and similar to modern cellular offices which make effective use of natural light. Economies arise from good levels of daylight, a fairly low density of occupation — particularly in common rooms and meeting rooms, the University's office illuminance standard of 300 lux (accepted after a study by the University's Working Party on Energy Conservation as sufficient together with a desk light where necessary), low-energy corridor lighting, and a predominance of small offices where a switch by the door is quite an effective means of control.

Office Equipment 3 kWh/m²

Although there is one terminal or computer per two persons, the terminals which predominate have a low energy consumption and are switched-off when not in use, as is the local VAX minicomputer.

Miscellaneous 9 kWh/m²

Apart from 1.3 kWh/m² for external lighting, this is largely from large-scale litho and photocopying equipment in the University's printing department, plus the associated humidity control equipment. The figure also includes local kettles etc at 0.5 kWh/m². There is no central catering or vending.

User Reactions

Initially there were complaints of cold spots, which were traced to problems with the optimum-start and high temperature cut-off room temperature sensor, which for economy was located near the boiler room and was influenced by heat gains from the main underfloor pipe duct. Performance was improved by substituting a group of internal sensors linked through the University's electronic Building Automation System.

In addition, several exposed rooms were cold owing to inadequate heat emitter sizing. Rather than running the compensated circuit unnecessarily hot, these now have local supplementary electric heaters, site-fitted with temperature-limiting thermostats. Their energy consumption is included in the Fact Sheet.

Solving these problems has increased Heslington Hall's energy consumption slightly, but this is in accordance with York University's policy to combine energy efficiency with good environmental conditions, where possible brought into line with the University's current standards.

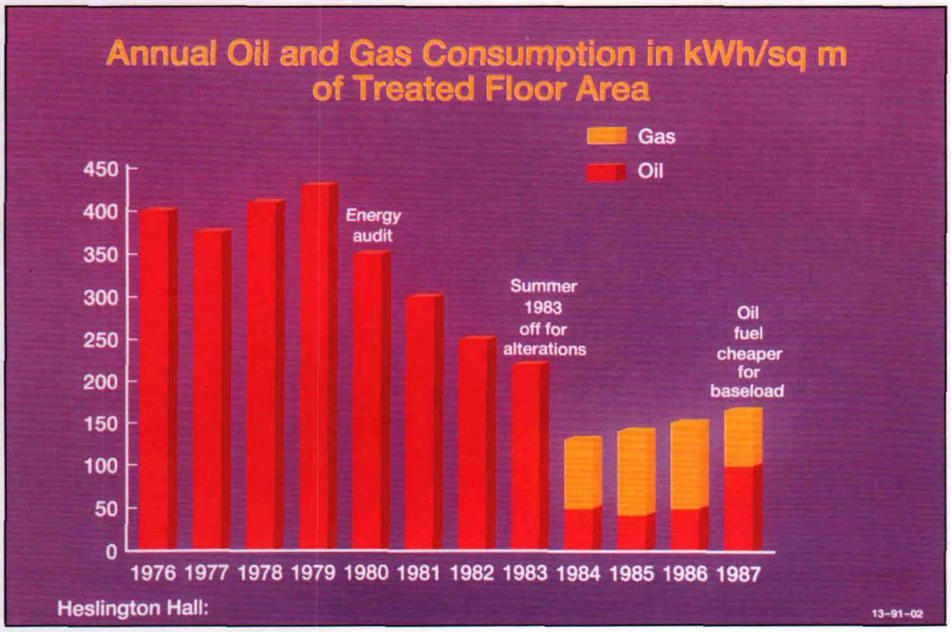
Internal view of office space

General Appraisal

Dramatic savings in Heslington Hall's heating fuel consumption have been achieved by applying current management and technology to an ancient building; in particular segregating the heating and hot water services and using a modern high-efficiency (though not condensing) gas-fired boiler. In this instance the building — in spite of its shallow plan and limited insulation — went from "very poor" to "satisfactory" in the CIBSE Building Energy Code Part 4's range.

The new boiler design has proved reliable and has since been used by the University in several new buildings and maintenance replacements.

Getting the new controls to work effectively required some effort. This is not unusual: not everything will meet both comfort and energy efficiency objectives first time round and all-too-often controls get over-ridden rather than understood and improved. The University's Maintenance Department has tackled both the technical and the human problems in bringing the project to a successful conclusion.



Annual oil and gas consumption

Main Conclusions

This Case Study demonstrates that major energy savings can sometimes be achieved cost-effectively in old, poorly-insulated, office buildings with a combination of good management and new technology, and without necessarily altering the fabric or removing elderly but still serviceable equipment.

In this instance the old oil-fired boilers were tolerably efficient provided that they were not called upon to service small or intermittent loads. The system is now managed accordingly, and the University can still make use of its original investment when oil prices are sufficiently low to outweigh the reduced thermal efficiency.

The review of the use of the facilities at Heslington Hall may be instructive with organisations who have several buildings, and where it may be cost-effective to cluster activities with extended hours into a few buildings rather than scatter them around.

The low lighting energy consumption also demonstrates the value of daylight in traditional buildings when combined with appropriate standards for artificial lighting.

Short Notes on the Measurement of Floor Area

Gross — Total building area measured inside external walls.

Nett — Gross area less common areas and ancillary spaces. Agent's lettable floor area.

Treated — Gross area less plant rooms and other areas (eg stores), not directly heated.

PRECISE DEFINITIONS ARE AVAILABLE ON REQUEST

All case study analyses in this series are based on an apportionment of at least one year's measured fuel consumption and cost. Further breakdown into sub-headings is by a combination of sub-meter readings, on-site measurements and professional judgement. The technique of apportionment is the same for each case study and all quoted building areas have been re-measured for the project.

This study has been carried out by the Davis Langdon & Everest Consultancy Group and William Bordass Associates. The cooperation of the owners, designers, managers and the occupants of the case study building is gratefully acknowledged.

Further information: Enquiries Bureau, Building Research Energy Conservation Support Unit (BRECSU) Building Research Establishment, Garston, Watford, WD2 7JR. Tel No. 0923 664258 Fax No. 0923 664097

Printed in the UK for HMSO Dd.8379518, 2/93, C400, 38938